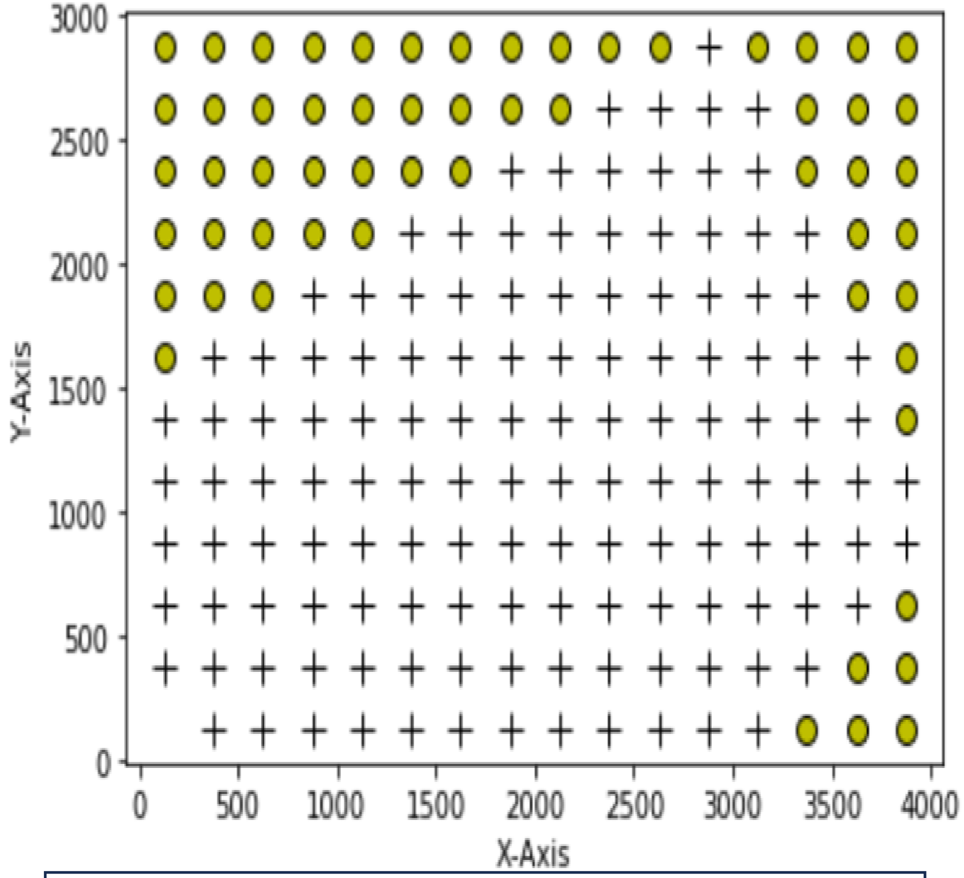
The 2-D Streamline Model for a planer Reservoir with Multiple Producers & Injectors using Finite difference Techniques new20b.ipynb



Active cell------ + **Non Reservoir --**

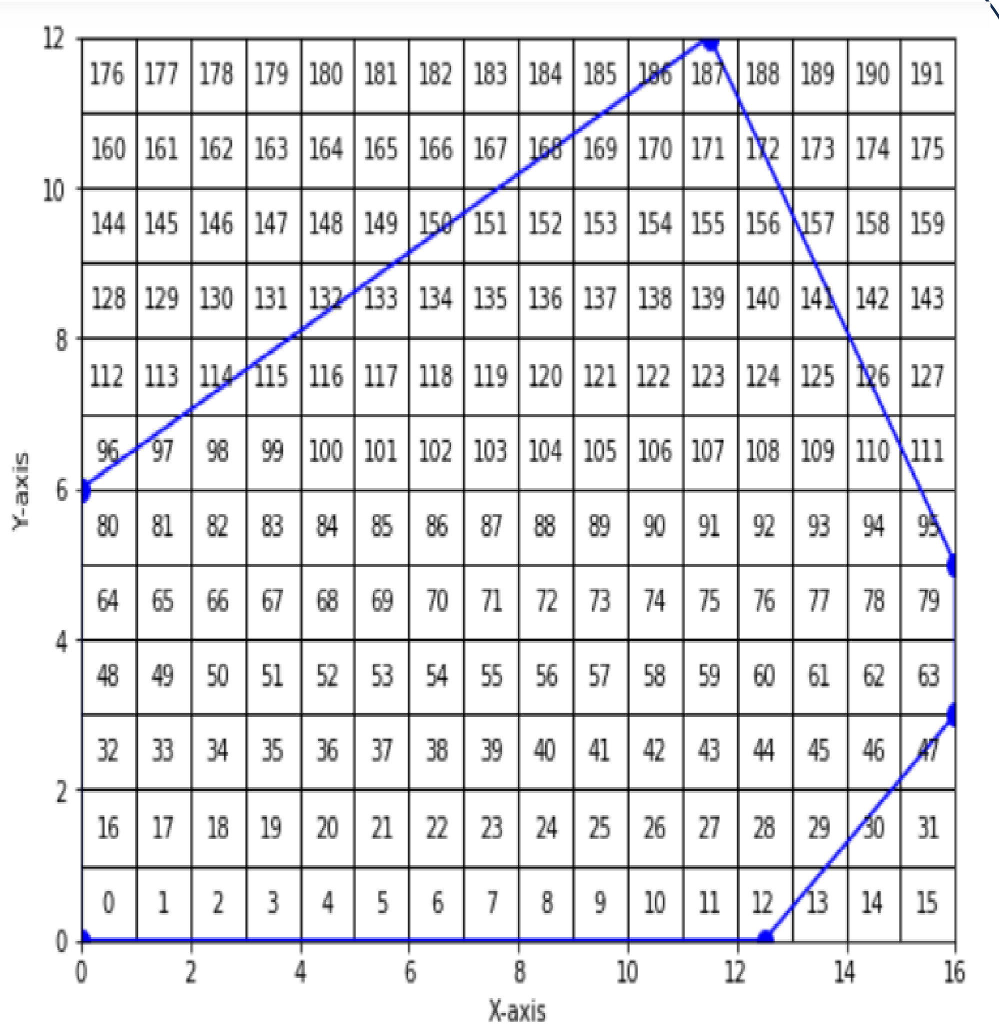
The pressure distribution under steady state for an arbitrarily shaped planer reservoir with number of producers and injectors is solved using finite difference techniques

A 2D grid is overlayed on the net to gross map of the reservoir and values are read cell by cell and row by row for net-to-gross in a file he.csv

Permeability values are also read in the same manner values are read cell by cell and row by row in a file permx.csv

The coordinates of the vertices are read in a file cord.csv

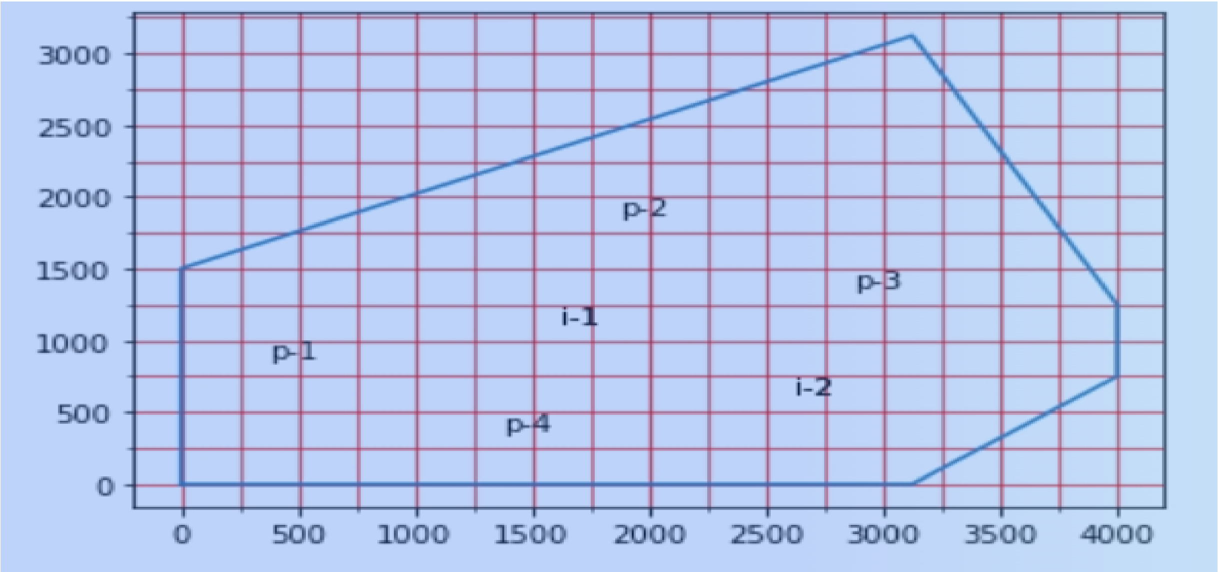
The well details are given in file well.csv



A typical rectangular grid enclosing the area of cells within the polygon are shown in the adjoining figure

The cells inside the blue coloured edges of the polygon are active cells while those outsides are designated net to gross of zero ,that is not participating in the production processes

The input data well.csv

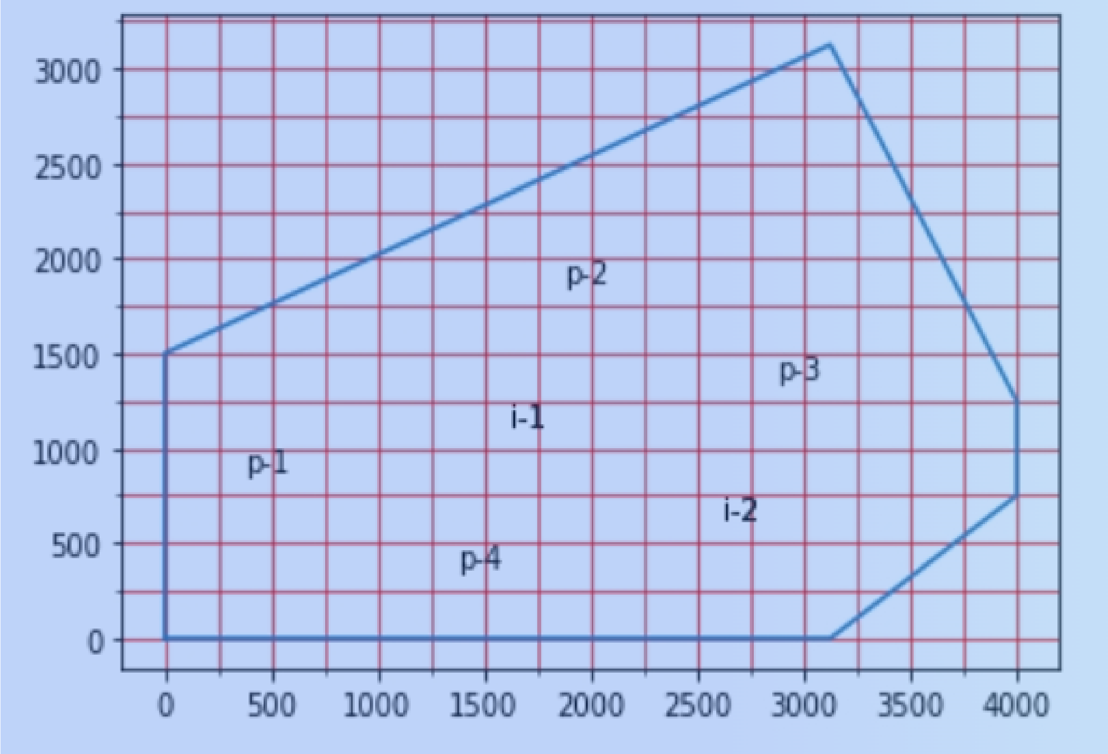


cell	xwell	ywell	rate	fw	name	east	west	north	south
49	375	875	-200	0.0	P-1	48	50	65	33
119	1875	1875	-200	0.0	P-2	118	120	135	103
91	2875	1375	-200	0.0	P-3	90	107	92	75
21	1375	375	-200	0.0	P-4	20	37	22	5
70	1625	1125	400	1.0	i-1	69	71	86	54
42	2625	625	400	1.0	i-2	41	43	58	26

The input data

Cord.csv

xv	yv
0	0
3125	0
4000	650
4000	1250
3125	3125
0	1500
0	0



The input data

Perx.csv
nxny entries

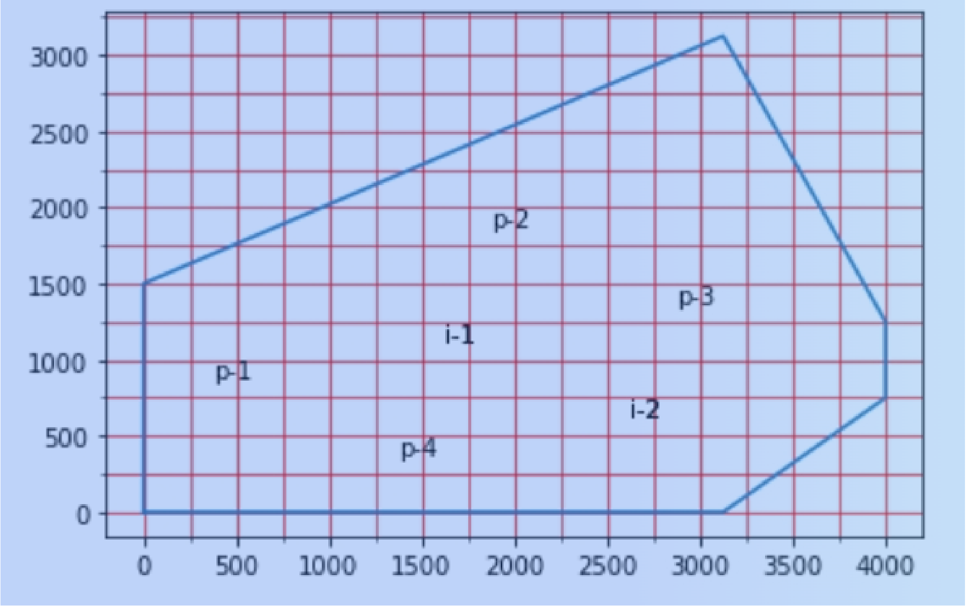
Cell number	x
0	100
2	100
3	100
4	100
5	100
191	100

Net to gross
nxny entries

Cell number	n/g ratio
1	1
2	1
3	0
4	0
5	1
191	0

pwf.csv
Type of grid block
0 – rate specified
1- pressure prescribed

cell	Grid type	pwf1	rate
21	1	2500	0
49	0	0	-200
91	1	2500	0
119	1	2500	-200
42	0	0	400
70	0	0	400



Data Required by program to be supplied Interactively

The program asks for the following inputs interactively:

number of rows: (nrows or ny)

number of columns: (ncols or nx)

viscosity : (muo) give 1 by default

displaceable porosity estimate : (pord) $\emptyset(1 - S_{wi} - S_{or})$

Number of producers: (np1)

x- grid size in feet : delx

y-grid size in feet : dely

Average pay thickness in feet: delz

In addition the program asks for delp to be given as a datum pressure in rate prescribed problems or zero if pressure is prescribed

Finally ,the number of streamlines considered to emanate from an injector grid block face

Data required to be supplied interactively

For running a prescribed rate problem, the value of delp is required

This is the value of datum pressure

For a prescribed pressure problem the value of delp is 0
Not required to be given
This program is run starting from points located on the injector faces as starting points
Input No of stream lines from the least flux face of injector: give typical value to be equal to 8(to start with)

Two varieties of problems addressed

Five Spot problem

Five spot Heterogenous problem

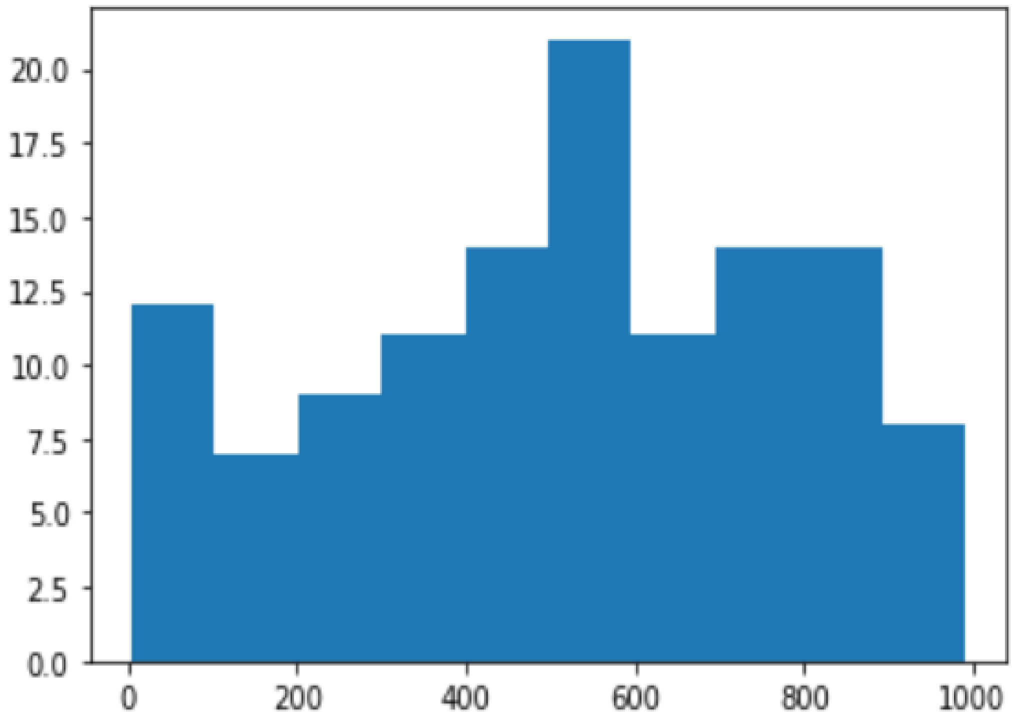
The Polygon problem

The polygon problem (well rates specified)

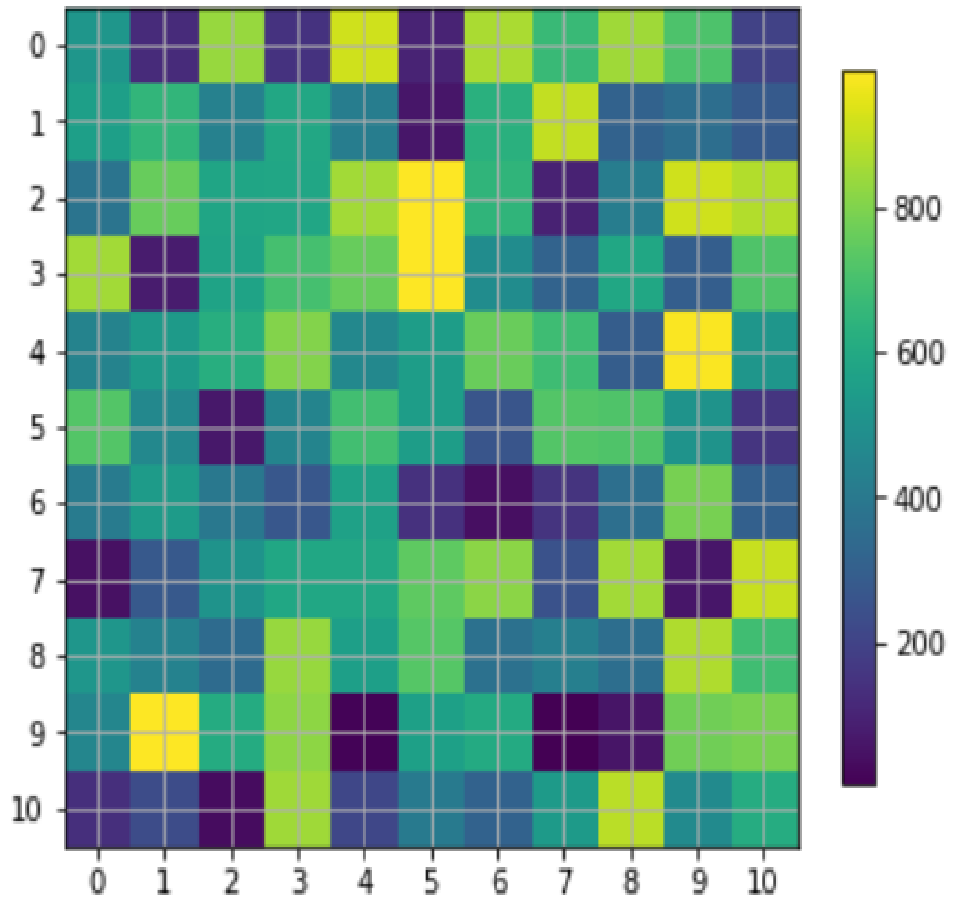
The Polygon problem (flowing pressures specified)

(1)In folder five_s relevant csv files are enclosed(homogeneous 5 spot case)
A typical symmetric five spot with 4 producer wells in the corner and central injector.
Files cord.csv, permx.csv, he.csv, prod1.csv and pwf.csv all are there
ny=11 nx=11, (121 grid blocks),phid=0.04, delx=700’. dely =700’ , delz=10’, reference pressure 2500 psi. This is a rate specified problem, each producer @125 b/day and injector at cell 60 is 500b/day. This is reflected in pwf.csv file.
4,8 or 16 streamlines, (choice is with user) to emanate from the grid block face with minimum

(2) In folder five_het (heterogeneous 5 spot case)
The same problem however there is significant heterogeneity in permeability with grid blocks assigned permeability randomly selected from a normal distribution of permeability varying from 1 to 1000md .The producers are assigned flowing bottom hole pressure of 2500 psi each and the rates of production are computed by the program. All other input csv files are same as in the five_s folder.

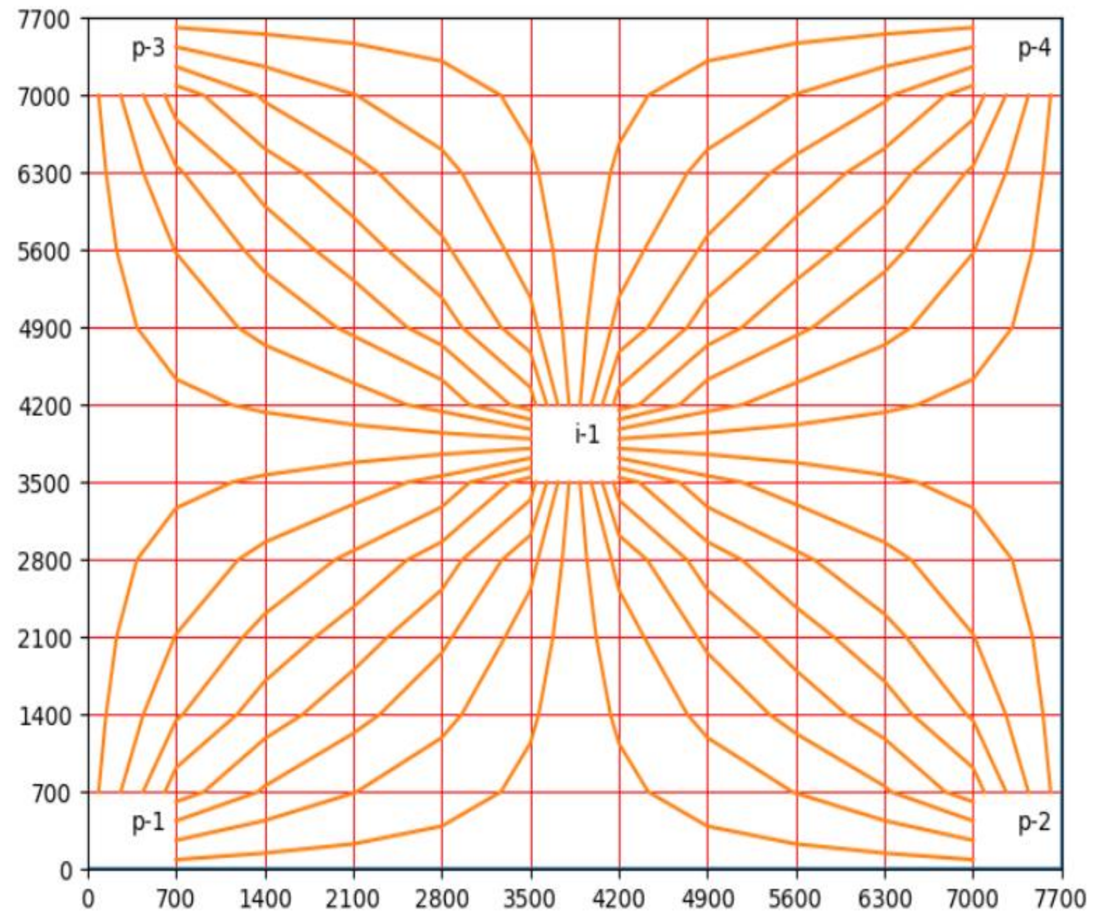


Histogram Of Permeability Values

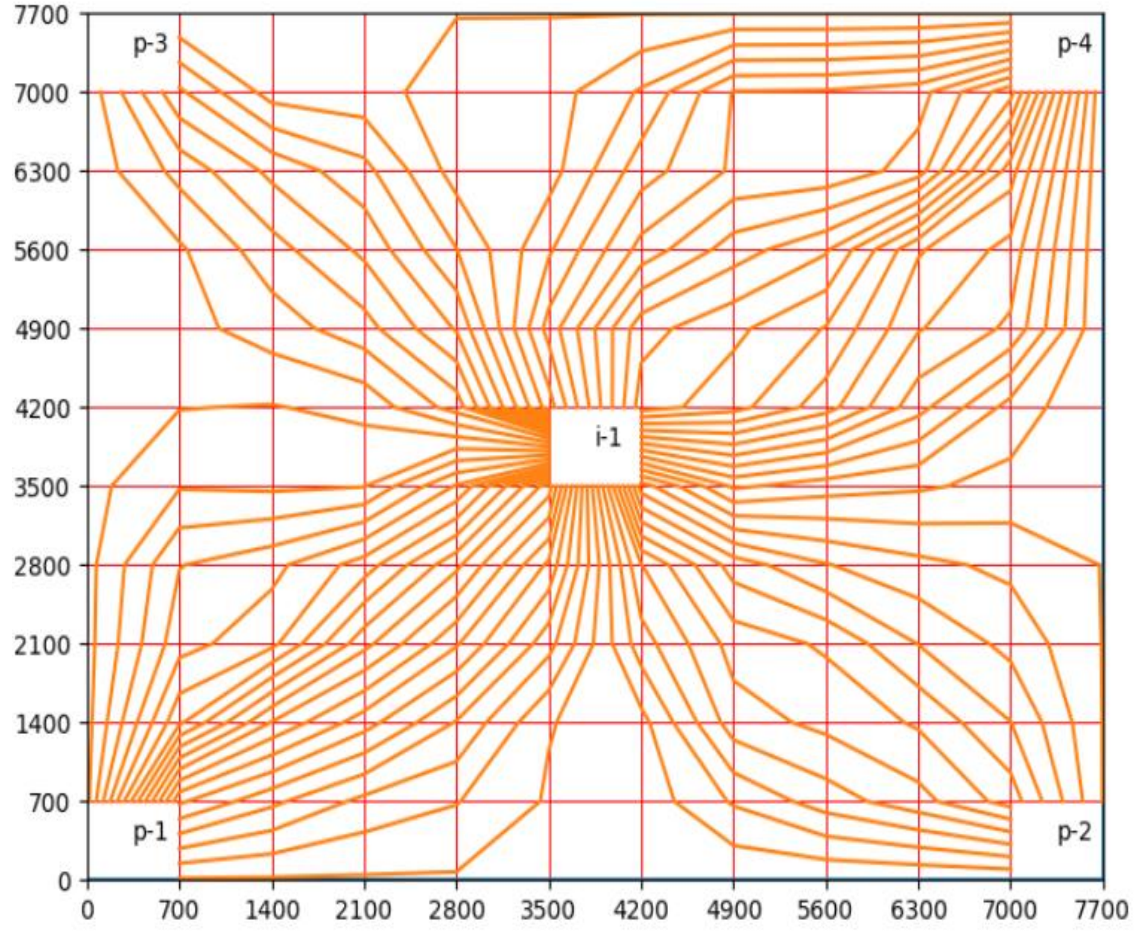


Distribution Of Permeabilities on the grid

Homogeneous Vs Heterogeneous five spot

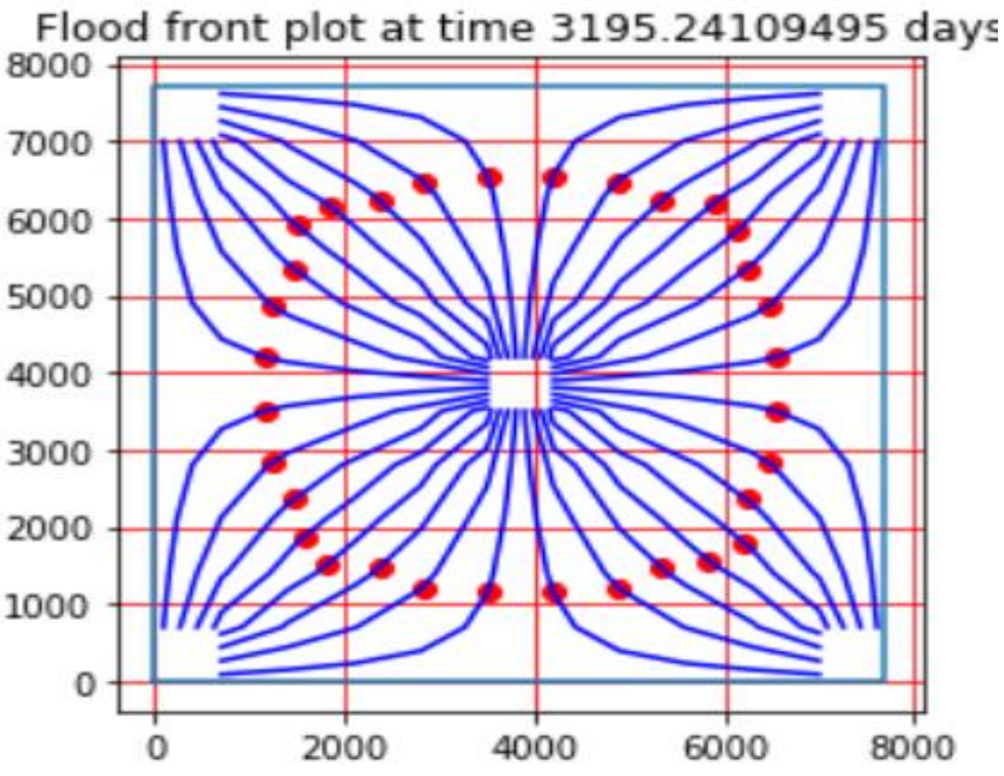


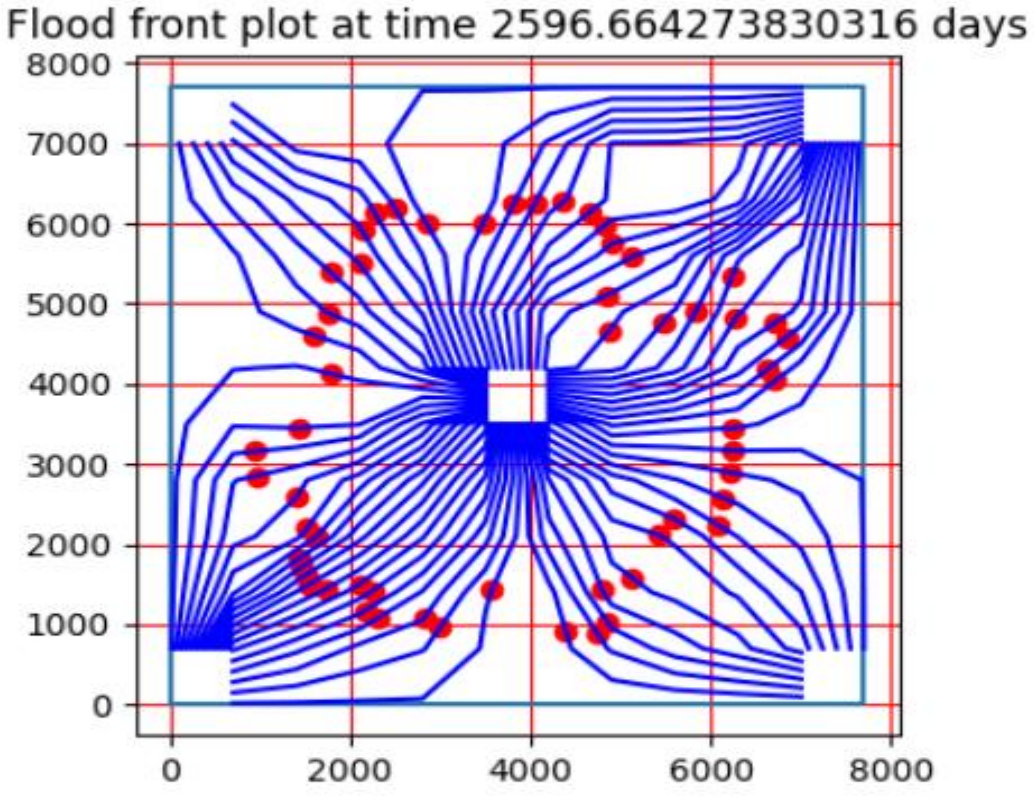
Homogeneous Permeability (100md) 11X11 grid



Random permeability distribution 11X11 grid

Homogeneous vs Heterogeneous five spot Performance difference

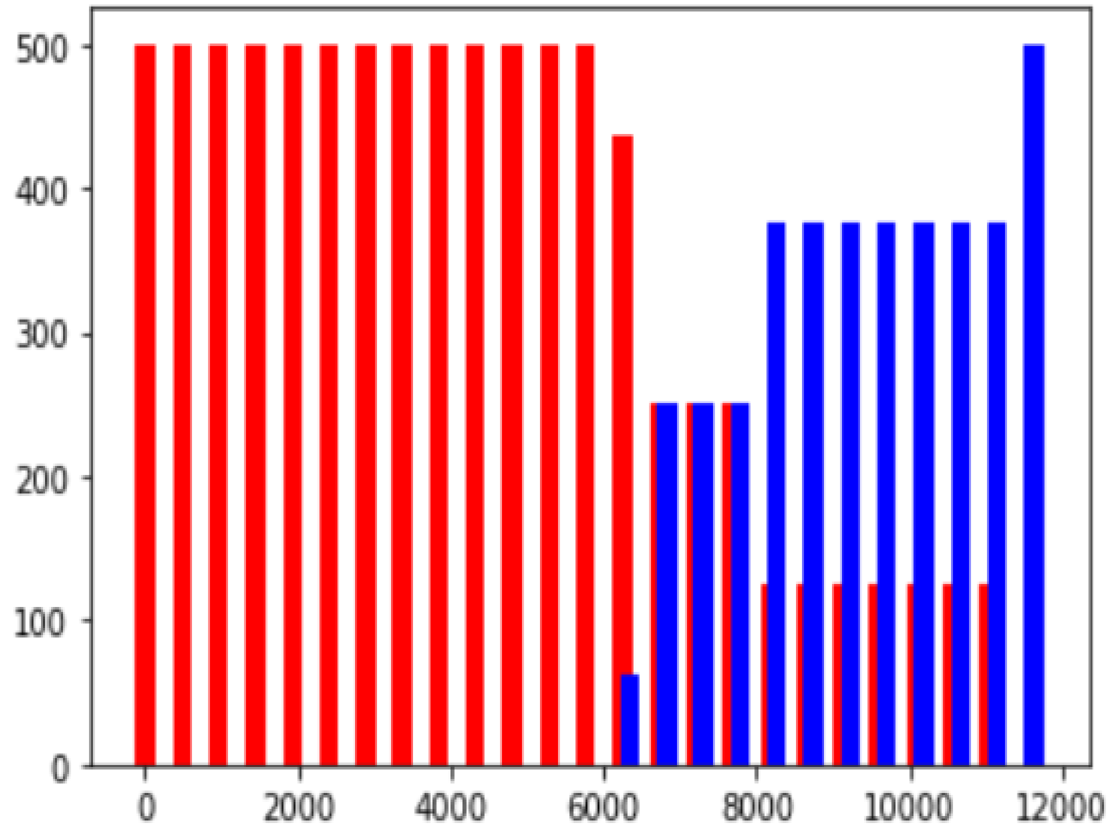


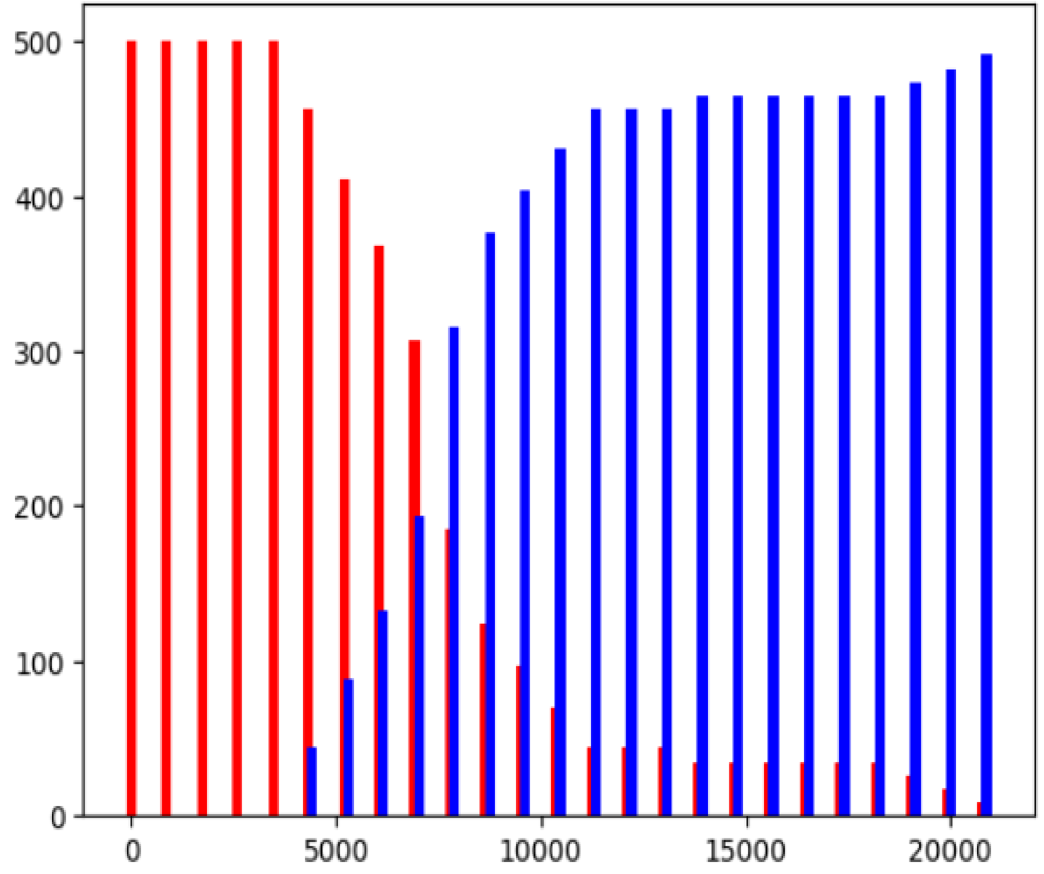


Homogeneous Reservoir Performance 5-spot

Heterogeneous Reservoir , Early Breakthrough, 5-spot

Homogeneous vs Heterogeneous five spot Performance difference





Homogeneous Reservoir Performance 5-spot

Heterogeneous Reservoir , Early Breakthrough, 5-spot

Problem 2 polygon problem

(1)In folder polygon relevant csv files are enclosed
Typical waterflood in a arbitrary shaped reservoir with 4 producers and 2 injectors is addressed. Files cord.csv, permx.csv, he.csv, prod1.csv and pwf.csv all are there

ny=12 nx=16, (192 grid blocks),phid=0.04, delx=250’. dely =250’ , delz=10’, reference pressure 2500 psi. This is a rate specified problem, each producer @200 b/day and each injector at cell 42 and 70 is at 400 b/day and pwf.csv reflects that
4,8 or 16 streamlines, (choice is with user) to emanate from the grid block face with 8 streamlines emanating from a face with least flux.
(2) In polygon _p
The same problem with the wells specified at prescribed flowing pressure(of 2500psia) instead of prescribed flowrate, the injectors at 42 and 70 cells are @400b/d This is reflected in the pwf file . All other input csv files are same as in the polygon folder.

Objective of the python script new20b.ipynb:

To obtain pressure distribution in an arbitrarily shaped polygon with multiple producers and injectors

To obtain the resulting streamline distribution along with breakthrough time distribution

To get a visualization of flowlines(streamlines) connecting producers to injectors

Obtain a quantitative estimate of how good a given producer well connected to a given injector

The Program is organised in 4 broad sections

Section 1 : Preprocessing and obtaining pressure solution

Section 2: Calculating velocity on the faces of every grid-block

Section 3:Generating and Plotting streamlines

Section 4:processing information to derive inter well connectivity matrix

Section 1: Preprocessing and obtaining pressure distribution

This has 7 subsections:
Subsection 1 : Processing Data2(prod1.csv) for further work
Essentially creates two lists prod_d and w_cell
prod_d is list of cell indices of all producers[21,49,91,119]
w_cell list of all cell indices[21,49,91,119,42,70]

Subsection2: A function for evaluating transmissibility of each cell

Subsection3 :creates a dg accumulating cell wise all information

Subsection 3:filtering dg removing all non-active (non reservoir) cells and creating dh

Section 1: Preprocessing and obtaining pressure distribution

Subsection 5:Setting up and solving the matrix equation using Numpy Linalg
Printing well wise calculated pressures

Subsection 6: Creating a dictionary d0 between cell index and computed pressures

Subsection 7: Writing grid-block pressures at all producers and injectors

Section 2: Computing Velocity distribution on grid-blocks

Subsection 1 : Computing wel, weli and dictionary weld

wel : prod_d, weli : list of all injectors [42,70] and

weld :a dictionary of cell number and the face

it shares with a cell containing producer

Subsection2: Assigning starting locations on faces of cells containing the injection wells

Subsection3 : Tracing streamlines from injection cell faces to producers and keeping track of breakthrough times

Section 3: Tracing and plotting streamlines

Subsection 1: This section traces streamlines using Pollock's Algorithm and plots them using matplotlib

Subsection2: calculates time of travel through an injection block

Subsection3: Def check3 checks which streamline has broken through in a given producer cell

Section 4: Obtaining Producer injector connectivity from the streamline model

The section writes important csv files

inp2a .csv: details streamline starting position on injector cell face and its end destination in producer cell also indicating breakthrough time

st2.csv: details of the journey of a given streamline though the grid

act.csv : tells whether any streamline has passed through a given grid-block (1) or not (0)

connect.csv: The matrix telling how much flux attributed to a given producer from which injector. This is very useful for Reservoir Monitoring